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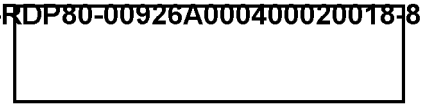

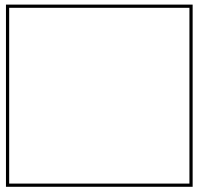

WATER RESOURCES OF SAUDI ARABIA

K. S. TWITCHELL

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WATER RESOURCES OF SAUDI ARABIA

K. S. TWITCHELL

FIG. 1—H. M. King Abdul Aziz Ibn Saud at Nuzla Palace, Jidda.

SAUDI ARABIA is probably the largest little-known unit area in the habitable world. There are no accurate maps of the country as a whole; in fact, all its boundaries have not been definitely established. Those still not surveyed or delimited are the southeastern in the Rub' al Khali, the eastern along the Qatar Peninsula, and a part of the northwestern boundary with Transjordan. The maps made by the Arabian American Oil Company of the eastern two-thirds of Saudi Arabia are the only accurate ones of that part of the country, and the airplane maps by the Saudi Arabian Mining Syndicate are the best of a large part of the Hejaz. Of individuals, the maps made by H. St. J. B. Philby on his many travels, including his survey of the Asir-Yemen boundary, are outstanding. The area of Saudi Arabia is about 700,000 square miles; if the Rub' al Khali desert is excluded, the "habitable" area is reduced to 550,000 square miles.

RELIEF AND RAINFALL

The realm of His Majesty King Abdul Aziz Ibn Saud is popularly thought of as a flat, waterless plain, an erroneous idea, corrected in part by the very names of the four component states: the Nejd, heart of Saudi Arabia, "high country"; the Hejaz, "boundary"; Asir, "difficult"; the Hasa, "stony."

The Hejaz consists of a coastal plain, the Tihama, 10 to 40 miles wide, and an igneous mountain wall rising steeply to 8000 feet. Eastward the mountains slope to the plateau of the Nejd, 5000 feet on the south, 1600 feet on the north. The lowest pass, so far as I have observed, is at 2180 feet. The average rainfall is estimated at 4 inches. The only regular records are those kept by the Saudi Arabian Mining Syndicate at the Mahad Dahab mine and at its Jidda office.

In Asir the mountain wall rises still more steeply from the Tihama to heights of more than 9000 feet. The plateau to the east is 6000 to 7000 feet

high at the foot of the mountains and slopes gently eastward to 4000 feet in the Najran and 3500 feet at the edge of the Rub' al Khali, the great desert or "empty quarter." The rainfall ranges from an estimated 12 inches on the western margin to practically nothing in the desert.

The plateau of the Nejd continues the general eastward slope to an elevation of 1200 feet along the Hasa boundary. The igneous rocks, exposed in the west, are overlain to the east by sedimentaries forming belts of sandstones, limestones, and chalk, eroded into cuestas with steep west-facing escarpments. The Jabal at Tuwaiq is a notable example. Along the western margin comparatively recent lava outpourings have created a most difficult topography, the *harra*.

The core of the Nejd is girdled by sandy deserts: the broad expanse of the Nafud in the north and the Rub' al Khali in the south are connected by sandy strips. The easternmost strip, the Dahana, presents a hard and gravelly surface in places but more generally consists of light, thin sands, not of the dune type. In the winter and spring there is in most sections sufficient grass for grazing during three months or more.

Gravelly and stony plains are particularly characteristic of the Hasa. The country continues the eastward slope to the Persian Gulf. Effects of the Persian Gulf tectonic disturbances are seen in some folding and steps due to slight faulting. There are many "thatched roof" islands left by erosion and due to the protective covering of chert. The rainfall seems to average 4 inches. The only regular and accurate records are those kept by the Arabian American Oil Company.

The water resources of Saudi Arabia may be conveniently classified according to these four divisions. I shall describe typical examples as I saw them during various trips from 1931 to 1942. The most extensive investigation related to water resources was made in 1942 on a trip of 10,700 miles in Saudi Arabia. This was the expedition sent in behalf of King Ibn Saud by the United States government. The United States Agricultural Mission to Saudi Arabia, as it was called, consisted of A. L. Wathen of the Department of the Interior as irrigation expert, J. G. Hamilton of the Department of Agriculture as agronomist, and the author as leader, because of his friendship with the King and his knowledge of the country.[1]

Resources in the Hejaz

Jidda is the principal port of Saudi Arabia. The permanent population

[1] K. S. Twitchell, A. L. Wathen, and J. G. Hamilton: Report of the United States Agricultural Mission to Saudi Arabia, 1943 (in English and Arabic).

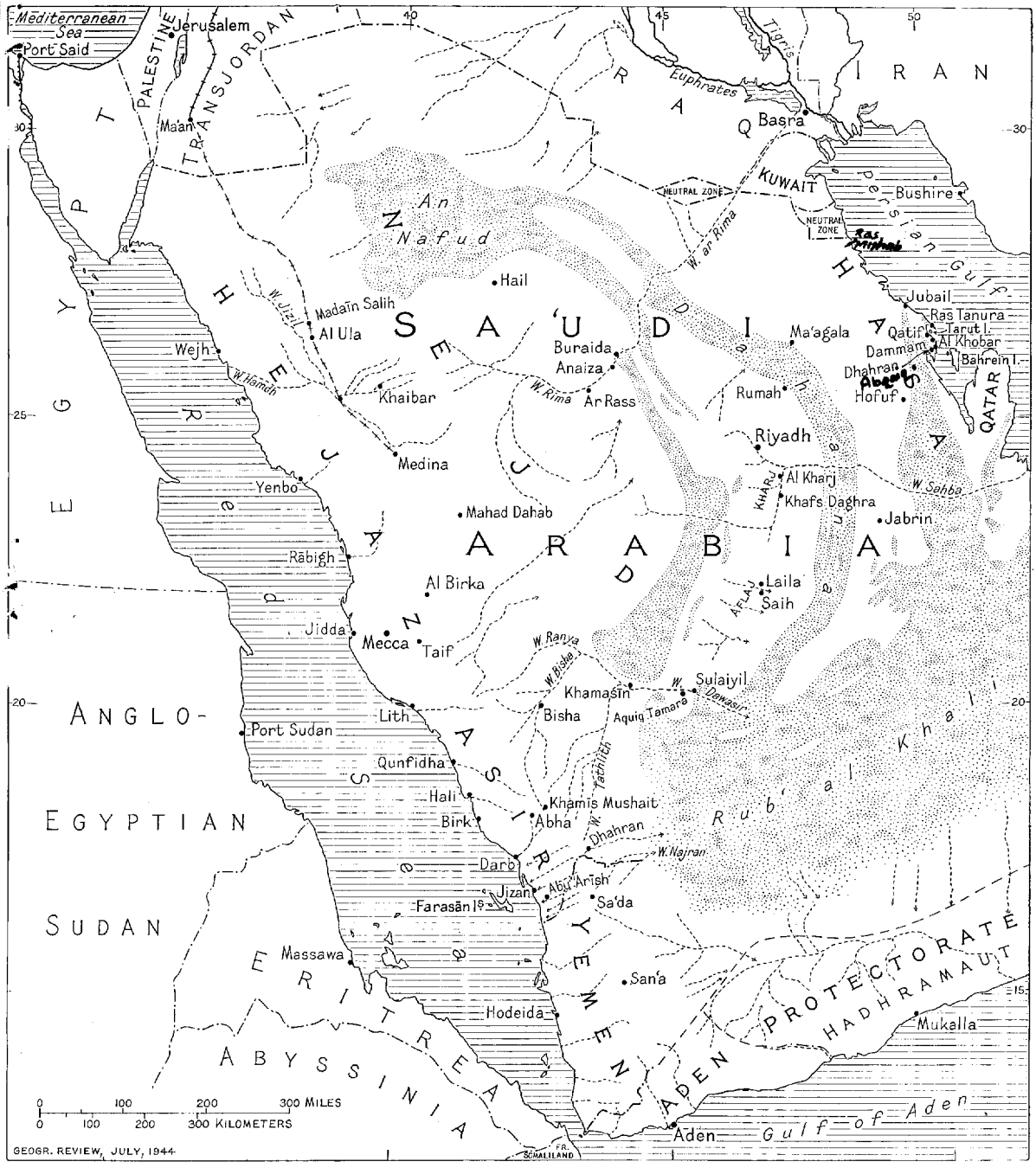


FIG. 2—Map of Saudi Arabia. Scale 1:12,500,000. The deserts, primarily sandy, are shown by stipple.

FIG. 3

FIG. 4

FIG. 3—The "cut and cover" method of water tunnel construction. This is an extension of the Wazaria water supply, 7 miles from Jidda.

FIG. 4—Al Birka cistern, on the road between Jidda and Mahad.

may be about 30,000; the number is greatly swollen by transients, for practically all sea-borne pilgrims land here to go to Mecca, 45 miles inland. The water supply of Jidda has always been a matter of concern. Long ago, it is said, ships were supplied with fresh water from the port. Two plants for condensing sea water were built under the government of King Ibn Saud in 1926 and 1928; the present average production is reported as 135 tons of fresh water in 24 hours. About 60 years ago the Turks constructed a water system of twin 5-inch terra-cotta pipes and a few miles of cut-and-cover tunnel to tap wells in a wadi bed 7 miles to the east, the Ain Wazaria. However, the water level receded, and Bedouin raiding led to the abandonment of this source. In 1932 the Wazaria water system was repaired and improved by the installation of a 16-foot windmill and an auxiliary Diesel pumping engine, gifts of Charles R. Crane. The water thus

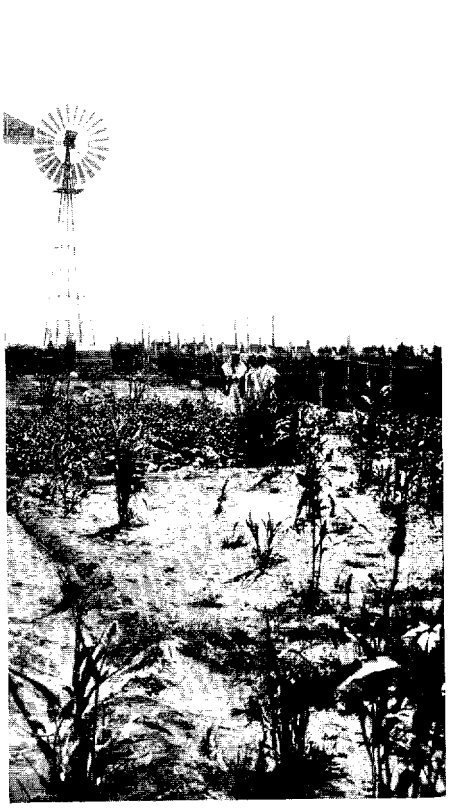


FIG. 5

FIG. 6

FIG. 5—The garden at Wazaria (see Fig. 8). Note the height of the Indian corn after 2 months' growth. Other successful plantings were six varieties of desert grass, beans, and tamarisk.

FIG. 6—Spring and oasis of date palms, Abu Dubah, Hejaz, near the burial place of the mother of Mohamed.

obtained ranged from 30 to 50 gallons a minute. An experimental garden established here has demonstrated that the soil, although sandy, needs only water to be productive (Figs. 5 and 8).

A third source of water is rainfall guided into cisterns and pits by small diversion dikes. The total daily amount obtained is estimated at 40 tons.

All water, whatever the source, is distributed by two-wheeled donkey carts carrying 40 to 60-gallon oil drums or by men, carts, and camels carrying 5-gallon gasoline tins.

The two other major ports of Saudi Arabia are Yenbo' and Wehj, respectively 200 and 400 miles north of Jidda. The water supply of Yenbo' is furnished by a condenser and cisterns, that of Wehj by cisterns adjoining the town and wells a short distance inland.

In the fertile Wadi Fatima, which lies between Jidda and Mecca, are

FIG. 7

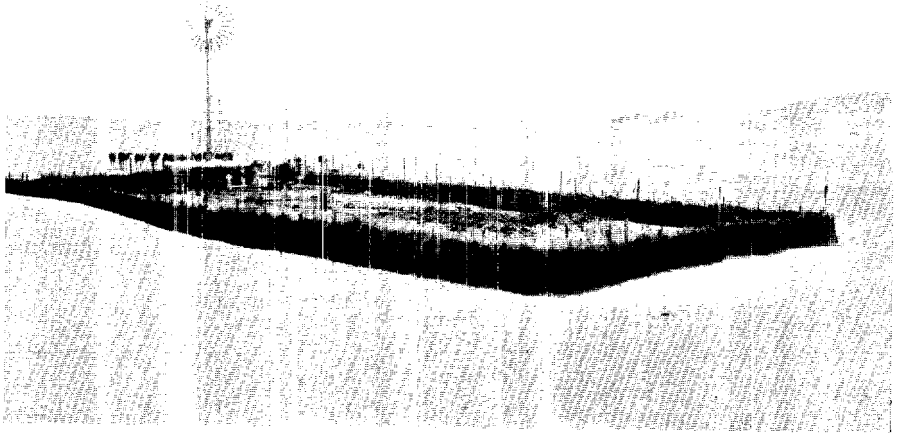


FIG. 8

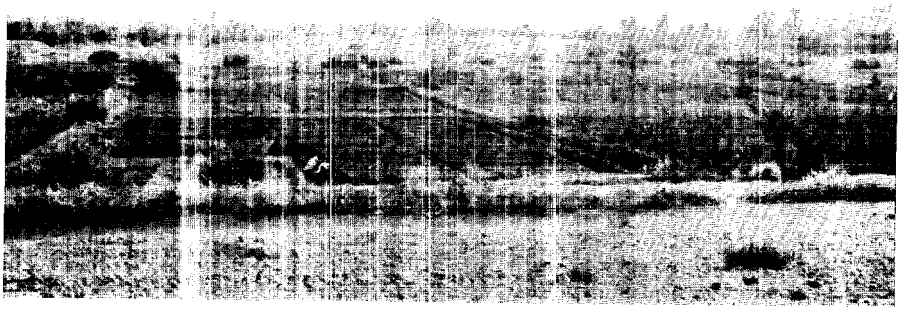


FIG. 9

FIG. 7 Terminus of Wazaria pipeline within Jidda city walls.

FIG. 8 The Wazaria garden (see Fig. 5), made in the desert to demonstrate the practicability of developing the water in that area, 1931 (now covered by drift sand).

FIG. 9 Sunken gardens in the Wadi Fatima, between Jidda and Mecca.

FIG. 10

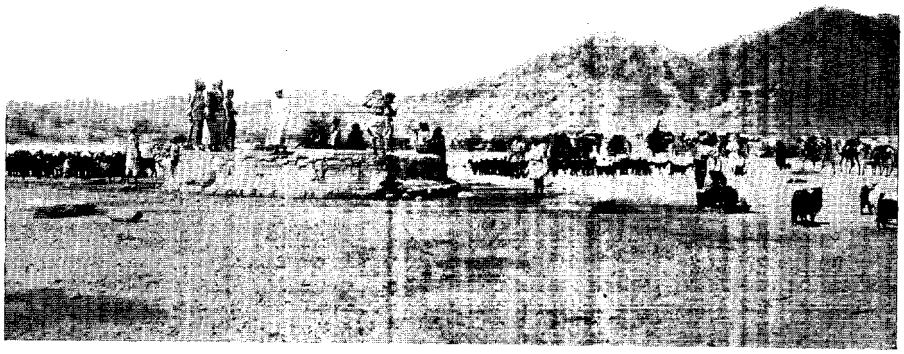


FIG. 11

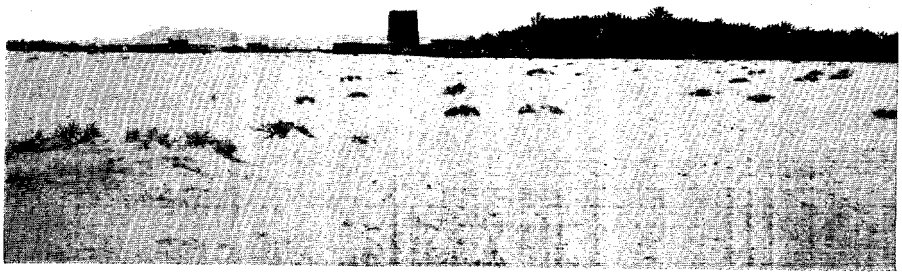


FIG. 12

FIG. 10—Sunken date groves in the Wadi Fatima.
FIG. 11—Bir Joharana, about 8 miles north of Mecca. Animals watering at large well.
FIG. 12—Farmhouse and date palms at Bisha, Asir.

many sunken gardens and date groves. An enormous amount of excavation has lowered the surface enough for irrigation by flowing water from springs in the hills to the north, and many miles of cut-and-cover water tunnels have been constructed (Fig. 3). A considerable amount of water, and also of surface area suitable for gardens, is available toward the center line of the wadi. Moreover, the water from the present cultivation could be re-used by low lift pumps, lifting from 18 to 25 feet. There is an ample market in Mecca and in Jidda for all garden produce that can be raised. The wadi could also furnish Jidda with water. About 28 miles of pipe line would be required, and no pumping would be necessary.

Mecca is the capital of the Hejaz and the holy city of Islam, forbidden to all unbelievers. The water supply is reported to come from Ain Zubaida, about 9 miles to the southeast, named for the wife of Harun-al-Rashid. The devout queen made several pilgrimages from Baghdad to Mecca and is said to have initiated the construction of cut-and-cover tunnels to bring water to Mecca (about A.D. 800). Queen Zubaida also had her engineers construct watering places at intervals of one day's march along the route. I have seen her wells and cisterns still in use. The cisterns show skill in the layout of dikes and diversion dams and in both material and construction of the masonry. There was a good deal of the small angular-aggregate type of lime concrete, especially in the linings of cisterns and sluices.

Taif is the summer capital of the Hejaz. Most of the Meccan government officials spend from May to October here in a delightful climate at an altitude of 5200 feet. The gardens of Taif, with their many varieties of fruits and vegetables, are famous. There are a few springs, but most of the irrigation water is obtained from wells in gneiss and granite, from depths as great as 90 feet, though the average lift is about 30 feet. I have seen remains of two masonry dams of well cut stone near here; others are reported. The age is unknown but is likely pre-Islamic. In the highlands to the south connecting with Asir many outlines of ancient gardens indicate a larger population and more efficient use of water in the past.

At the present time Prince Faisal, second son of Ibn Saud, and Shaikh Abdulla Sulemman, minister of finance, are expending much money and energy in reclaiming and enlarging cultivable areas about Taif. Most of the water resources are being put to use. The renovation of dams and selection of new damsites will permit storage of flood waters to augment the present supply. Between Taif and Al Sale there is a perennial stream in a deep canyon, which should be investigated for such a purpose.

There are large unused subsurface resources and considerable arable

areas in the great Wadi Hamdh, which heads near Medina; for example, at Malaliya, 50 miles northwest of Medina. The water table is 8 to 20 feet below the surface, according to the time of year. The soil is alkaline in spots, but dates thrive, and in most places various sorghums and alfalfa. Similar areas were seen for miles along this wadi and also along the Wadi al Jizil, where now is no habitation. In the Jizil and its branches and in the wadies 'Ula to the north and Ais to the southwest are many ruins of villages and water tunnels. Judicious planting of tamarisk trees to protect riverbanks and dikes and to provide fuel, in combination with adequate pumps, should bring into production an area large in the aggregate, though the units would be small, 5 to 10 acres. Arabic history refers to the richness and fertility of this district. A possible damsite about 600 feet long at its base was found on the Wadi al Jizil 21 miles from its junction with the 'Ula. Although the area below this site is not large, it merits close examination.

Resources in Asir

Associated with the greater elevations in Asir is the greater rainfall, estimated on the basis of the vegetation at 12 inches. The western slopes are too steep for any appreciable cultivation, but the gentler eastern slopes are terraced in the way common in the Mediterranean countries. Some of the terraced fields are irrigated, but most of them seem to rely on rainfall. Protection against soil erosion and the use of water are efficient. Without such a system this area could support only a small fraction of its present population, though unused fields indicate a still larger population in the past. Figure 13 is typical of the eastern mountain slopes from the Yemen to Taif, a distance of more than 300 miles. The rainfall decreases eastward, but the runoff gathered in the numerous wadies is utilized by means of diversion dams and wells.

On the southern border of Asir is the well watered valley of the Najran, which has its sources in the lofty mountains of the Yemen. It was reported to the Agricultural Mission that twenty-five floods came down the wadi during 1941. All persons questioned agreed that there were never fewer than five floods a year and usually about fifteen. The signs of erosion on the banks confirm the reports of numerous floods and indicate some of great volume.

Himyaritic ruins in the Najran suggest a more intensive cultivation and a larger population than at present. Among these ruins are the remains of an ancient dam called Sud Mufija at the head of the valley. Fragments of a lime concrete are seen in one of the sluiceways cut out of the coarse-

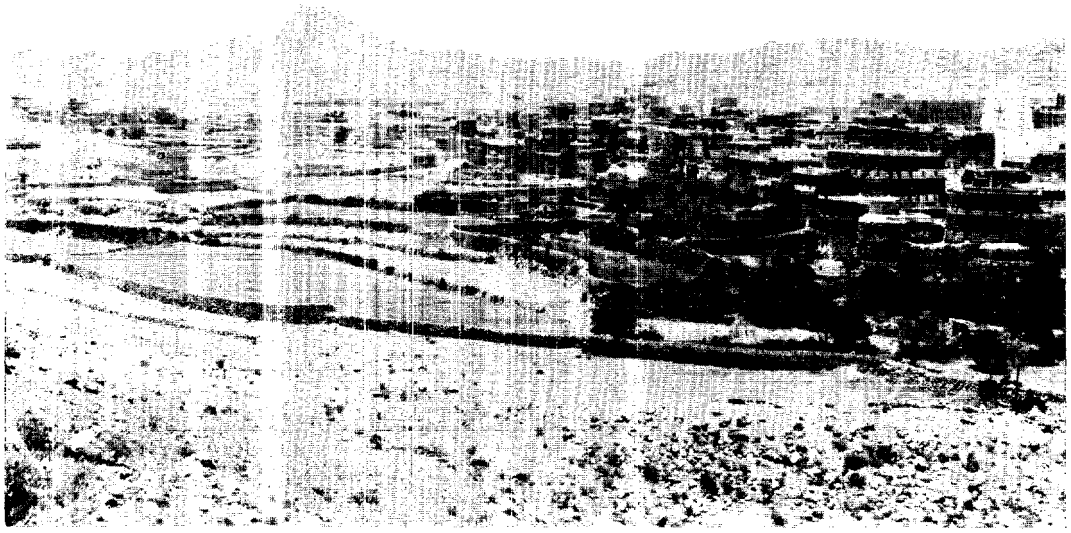


FIG. 13.—General view of Abha, capital of Asir, elevation 7000 feet; terraced fields mostly watered by rainfall.

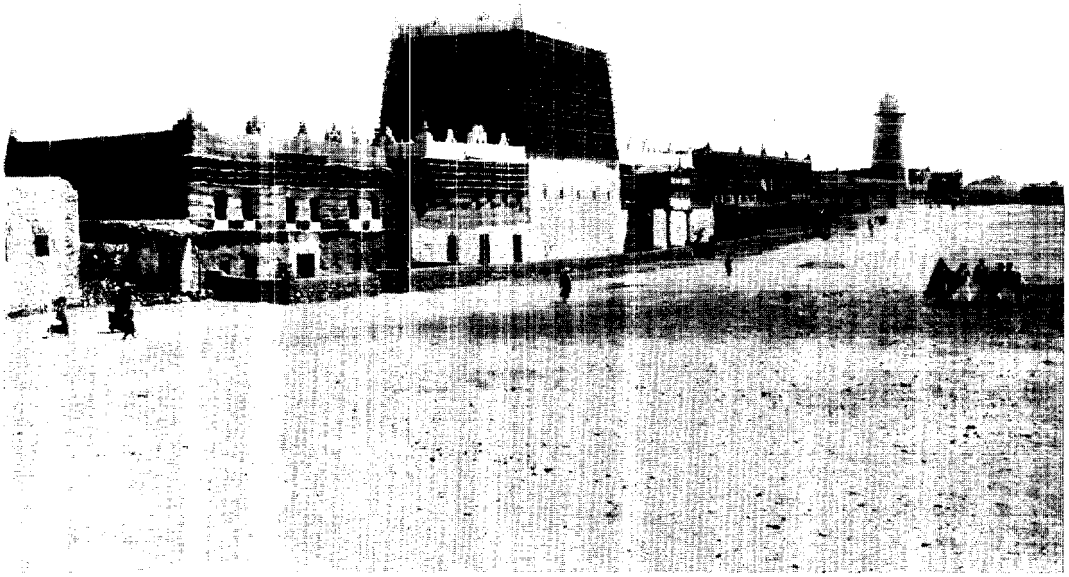


FIG. 14.—Offices of the director of finance at Abha.

FIG. 15—Typical farmhouse and fields of alfalfa and dates in the fertile Najran. Elevation 4000 feet.

FIG. 16—Zaharan (Dhahran), between Abha and Najran.

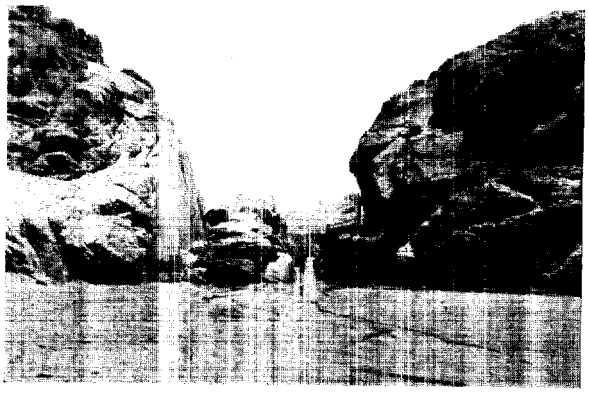


FIG. 17 Ancient ruined dam at Mufija, Najran.

grained granite The basin above this dam has too steep a grade to warrant its rehabilitation, but four miles downstream at Jabal Raoum there is an excellent damsite. The mission recommended that a gauging station be established and records kept.

The ruins of the city of Ukhdūd are evidence of a considerable ancient civilization. The city was probably located along the edge of the river, which has since changed its course. There is a large fresh-water spring near the ruins. The wells throughout the 15 miles of the valley indicate that the water table is 12 to 15 feet below the surface and varies little throughout the year except during the floods. It is estimated that only 20 per cent of the arable area is under cultivation. If the Jabal Raoum dam is feasible, a large additional area could be reclaimed. Soil and climate are as favorable as the abundant water supply, and the raising of dates, sorghums, sugar cane, wheat, alfalfa, numerous fruits and vegetables, and cotton offers an attractive prospect. Ruchdi Bey, the royal chamberlain at Riyadh, told me that the ancient histories record an unsurpassed sugar cane grown in the Najran. Development today is handicapped by lack of capital, technical knowledge, manpower, and transportation.

Farther north is the great Wadi Bisha, which draws on an immense watershed in the mountains of Asir. The river flood plain is half a mile to two miles wide and carries a great volume of water several times a year; for the rest of the time, water is derived by infiltration. Wells are 30 to 50 feet deep, according to the elevation of the ground surface. The water level is reported to remain constant. To the east this wadi joins the Wadi Dawasir. Another large tributary of the Dawasir is the Tathlith. The deep cuts in the silt banks of the Bisha and the Tathlith testify to the great volume of water and soil carried down by these streams. Ruins reveal the extent of former cultivation, and palms prove that water is still available and that a larger population than at present could be supported along both these wadies. The main feeder of the Dawasir to the north is the Wadi Ranya.

On the Dawasir, from the village of Khamasin to Sulaiyil, the water table is 2 to 4 feet below the surface. Although the water is brackish in many places, there are almost continuous date groves and settlements between the two towns. Near Aquiq Tamara there are ruins of an extensive town. I saw some new date plantings near here when I visited this district in 1940. Considerably more water is available than is now being used.

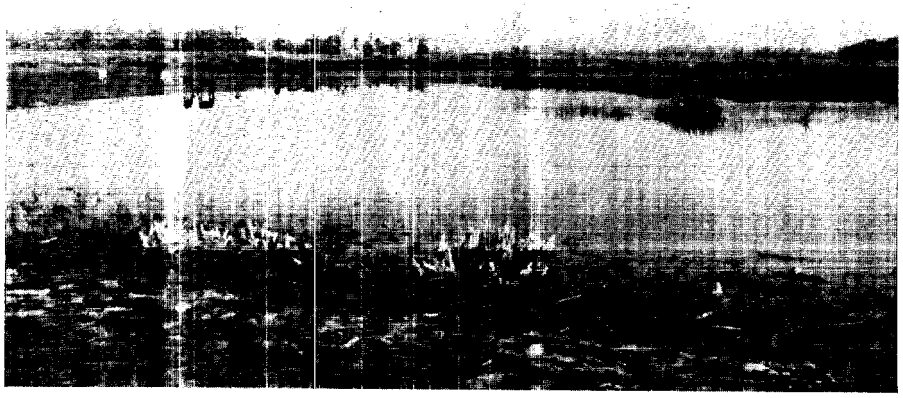
FIG. 18—Jebel Raoum dam site, Najran.

The mission recommended that *athel,*[2] or tamarisk, be planted in many places along the riverbanks and in the flood plains of the wadies Tathlith and Bisha. These rapidly growing trees would furnish timber, lumber, and fuel; and the last, in the form of charcoal, could be used in gas producers to operate pumping engines, thereby putting under irrigation land now desert because it lies above the river bed. Soil and climate are suitable for citrus fruits as well as for dates, sorghums, alfalfa, some grains and cotton, and vegetables. The dates of Bisha have the reputation of being the finest in southwestern Arabia.

On the Red Sea side of Asir, in the Tihama coastal plain, thickly inhabited areas extend from the Yemen frontier to Lith, a distance of more than 300 miles. These are the cultivated patches that line the wadies from the mountains almost to the seacoast. They are separated by areas of desert, in places by lava flows reaching to the sea. Cultivation is entirely dependent on the river floods, which, it is said, seldom fail. The extensive systems of diversion dams and dikes are designed to use all the water regardless of the size of the flood, by a method similar to the *bolsa* type of irrigation of southern Arizona and Mexico. Leveled and diked fields utilize the last drop of water of the greatest floods, though they may yield crops only once in several years. Diking and drainage show great skill. Only one crop is raised annually, almost exclusively red and white grain sorghums.

The waters of some rivers are not utilized, however (the Wadi Samra and the Wadi Bedth between Darb and Baish, for example), though large

[2] The U. S. Bureau of Plant Industry uses this spelling (information from Paul Russell, Division of Plant Exploration and Introduction); Philby has *ithil.*



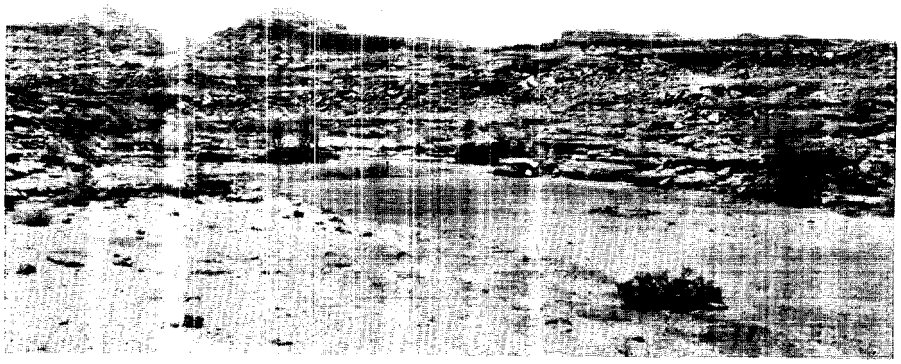


FIG. 19– The springs of Ain El Hussein, 4 miles east of Najran fortress.

FIG. 20– On the threshold of the Rub' al Khali, Bir Hima. Wells (water at 10 feet) in the aeolian sandstones.

FIG. 21– The date groves of Khaibar, Nejd, growing in the valley between huge tongues of lava.

flood flows reaching the sea are reported to occur yearly. The water of the few wells in this coastal area is used for drinking only. It is probable that a considerable addition to vegetables and fruits could be obtained by sinking more wells. The depth to water ranges from 27 to 110 feet.

Resources in the Nejd

The travels of the mission in the Nejd extended as far north as Hail, southeast of the Nafud. Here the water resources are being efficiently developed and used to the limit. All water was being raised, the depths ranging from 30 to 80 feet.

To the southeast of Hail at 'Anaiza excavations were being made in the bed of the Wadi ar Rima, to lower the level of the date gardens, as is done in the Wadi Fatima near Jidda. These garden pits are 3 to 7 feet below the surface (see Fig. 22). There seems to be an enormous amount of water in the wadi, at a depth of 15 to 27 feet below the surface. There are many settlements now along the Wadi ar Rima, but formerly there were even more. All the water is raised by pumps, usually of the skin-bucket type, hoisted by camel or donkey. But at one place 7 miles north of 'Anaiza there is a small, shallow artesian-water area. The boreholes are churned down by hand-operated tools through gravel and hard sandstone to tap the aquifer. Several of the wells yield flowing water. From here to Ar Rass along this great wadi there seems to be ample water at a reasonable depth to support a much larger population. Soil and climate are good.

Khaibar represents a different type of country—the volcanic harra. It lies on the western border of the Nejd, a hundred miles north of Medina, at an elevation of 2200 feet. The date groves of Khaibar extend down a deep valley between huge tongues of lava, from which issue many springs. The greatest need in this district is adequate drainage to prevent alkalinity and to reduce the amount of malaria, a serious drawback. About 15 miles southeast of Khaibar village is the first of six masonry dams, Sud Hasid, 182 feet long at its base and 270 feet along the crest, and 28 feet high above its stone pipe outlet. Its capacity has been estimated by A. L. Wathen at 750 acre-feet. The porosity of the lava banks prevents increase of capacity, but the dam could be put into service at small expense by installing a simple outlet gate and grouting or chinking the cracks caused by settlement. Renovation of the other dams would entail a little more work and expense. Double triangle inscriptions near Khaibar confirm the legend that the dams were built by Jews, at a time said to be about A.D. 400.

Any description of the water resources of the Nejd would be incomplete

FIG. 22—Sunken date gardens at 'Anaiza.

without reference to the wells along the main caravan routes. They are vital to travelers and to the Bedouin tribes, with their herds of goats, sheep, and camels. The inflow is usually not large, ranging from 5 to 30 gallons a minute.

WATER PITS OF AL KHARJ, KHAFS DAGHRA, AND AL AFLAJ

Al Kharj is the name of a district which is the nucleus of reclamation projects initiated entirely by the minister of finance and the King. The new village constructed at the center of this area is also named Al Kharj. It was because of the interest created by this work that the Agricultural Mission to Saudi Arabia evolved.

The amazing water pits of Al Kharj, Khafs Daghra, and Al Aflaj are actually gigantic natural wells. They are located along a generally north-south line. At Al Kharj (1360 feet elevation, aneroid), 56 miles southeast of Riyadh, are three pits; 27 miles southwest of Al Kharj is the Khafs Daghra pit; and 156 miles from Al Kharj (1680 feet) are the five great Aflaj pits.

Two of the pits at Al Kharj, Ain Semha and Ain Dhila, are each about 300 feet in diameter by 420 feet in depth (Fig. 25). That they are connected underground is proved by the lowering of the water level of both when one is pumped. The pits probably are the result of simple solution and caving in of the cavern roofs in the limestone strata. At Ain Umm Khissa, a mile west of Ain Semha, a distinctly hollow sound is heard as one walks around the south side of the pit. This pit is only 45 feet deep, but it probably derives its water from the same source as the other two pits—the rainfall on the watershed of the Tuwaiq Mountains to the west and southwest. The oil geologists reached this conclusion after extensive investigation.

At Ain Semha about 14 cubic feet a second is being pumped, which lowers the water level 14 to 15 feet. In the reclamation project worked out for the Al Kharj area by the engineers of the California Arabian Standard Oil Company for the Saudi Arabian government it is estimated that pumps with a capacity of 100 cubic feet a second will have a drawdown of 100 to

120 feet. The area to be irrigated is estimated at 3500 acres.[3] Because of wartime conditions, the equipment recommended cannot be supplied, but through lend-lease arrangements and recommendations of the mission, four pumps with a capacity of 4500 gallons a minute each and four suitable caterpillar Diesel engines to operate them were shipped in October, 1943. A single unit of the same type was shipped in November, 1943, to test inflows at Aflaj. This equipment arrived in the early spring of 1944.

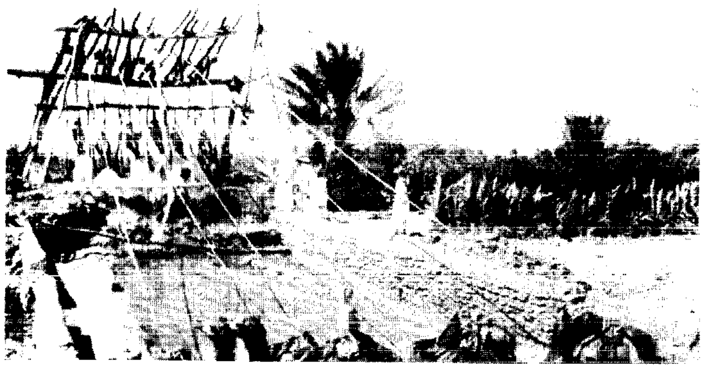
The Khafs Daghra water pit is similar. It is about 150 feet in diameter and of unknown depth and now irrigates some 800 acres. Wheat is the principal crop, of better quality than that at Al Kharj.

Of the five water pits at Aflaj, all except one are much larger than those at Al Kharj. The largest, Ain al Rass, is about half a mile long. Its water surface is 27 feet below the rim; the depth of the water is unknown, but it was reported that a 400-foot rope failed to reach bottom. At three different levels in the mouth of the pit are the remains of ancient irrigation ditches, which indicate that during the past two thousand years, more or less, the water table has been lowered 27 feet, possibly because of a change in climate and rainfall. Three of the other pits are connected, and they may also be connected with Ain al Rass, half a mile to the south. But Ain Shughaib, about 1200 feet to the west, is 15 feet higher. The mission suggested that a short tunnel be constructed to tap this water supply and lead it to the ditch running from Ain Botn, thereby augmenting the water for irrigating the date groves at the villages of Saih, Saih Jenubia, and Laila, the principal settlements of the Aflaj district. To the east and north of these villages is a great stretch of level land with silt-loam soil well suited to wheat, small grains, and rice. A renovated well showed the water table to be 42 feet below the surface and the water of excellent quality. There are good prospects for a large reclamation project in this area if the quantity of water comes up to indications.

Eastern Hasa

The greatest water resources of Saudi Arabia are in the eastern Hasa. For a distance of perhaps a hundred miles from the Persian Gulf coast and parallel to it for some hundreds of miles there are possibilities of flowing artesian wells. The oil company has drilled such wells at its camp at Abqaiq and other camp locations and also on the road to Hofuf a few miles west

[3] R. A. Bramkamp, T. C. Barger, and L. M. Snyder: Report on Development of Saudi Arabian Government's Irrigation Project at Al Kharj, Saudi Arabia, California Arabian Standard Oil Company, Dhahran, Saudi Arabia, 1941.



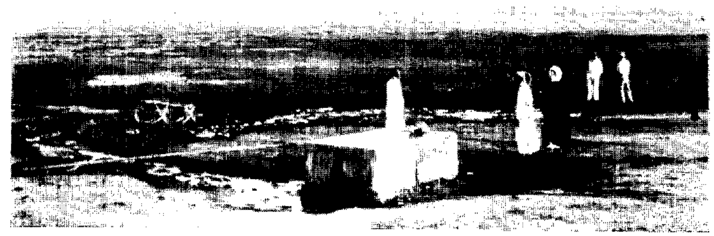


FIG. 23—A six-skin camel-operated well at Yamama in the Al Kharj. It is typical of the method of raising most of the irrigation water in Nejd and Hejaz.

FIG. 24—Three of the great water pits of Aflaj, of unknown depth but said to exceed 400 feet.

FIG. 25—Ain Semha water pit, one of the two great natural wells 420 feet deep being used in the Al Kharj reclamation project.

FIG. 26—Flowing artesian well at Jowia, on the Dhahran-Hofuf road.

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FIG. 27—Hofuf oasis. One of the main canals from the great spring Al Haqal. A rough measurement gave 22,500 gallons a minute.

FIG. 28—Hofuf oasis. Main drainage ditch discharging toward Jenubia. With some additional water it will be possible to water 5000 acres.

FIG. 29—Hofuf oasis. Transplanting rice. Rice is sown thickly but after a firm growth is started it is transplanted, as is the practice in the Far East.

FIG. 30—Ain Al Saba, Hofuf Oasis. The estimated discharge is 20,000 gallons a minute.

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of Abqaiq, and the Saudi government has drilled a well at Hofuf. Several wells have been drilled privately between Dammam and Qatif. Artesian drilling was initiated by Major Frank Holmes on the island of Bahrein about 1930. In addition to this man-made water supply, there are astonishing springs of flowing water in the immense oasis of Hofuf, at Safwa near Qatif, in the Persian Gulf a short distance north of Jubail, and on Bahrein Island.

Along the coast the average depth for tapping the artesian flow is about 300 feet, but at Hofuf it is, I think, about 700 feet. It is believed that the water-bearing strata must be fed from the Tuwaiq Mountains.

The Hofuf oasis is by far the largest and most productive in Saudi Arabia. Its average elevation is 500 feet (aneroid). The area planted to date palms is reported by engineers of the oil company to be 25,000 acres, the number of palms 2,000,000. I believe these figures are very conservative. Nine main springs irrigate the palms and many fields of rice. I list them below with the estimated flow. With one exception, Ain Haqal, which I measured, the estimates are those of A. L. Wathen.

	GALS./MIN.		GALS./MIN.		GALS./MIN.
Al Haqal	22,500	Al Saba	20,000	Huaira	2,000
Al Hadud	20,000	Mansur	4,000	Thuraib	1,000
Al Harra	20,000	Joharia	3,000	Bahali	800

The total discharge is 93,300 gallons a minute, or 207 cubic feet a second — virtually a young river. There are two areas of 5000 acres each that could be partly irrigated by water now going to waste.

All through this great oasis there is need for much more efficient drainage; this is true also of the Qatif area and the Persian Gulf coast.

As was previously mentioned, a large acreage along the coast from Dammam to Qatif is being reclaimed by the drilling of artesian wells. The mission recommended that all wells be provided with valves, to be opened only when water is being used and thus cut down the present waste of the water supply, which is far from limitless.

At Safwa, a few miles north of Qatif, there is a large flowing spring called Ain Harush (Fig. 33). The flow was estimated by A. L. Wathen at 9000 gallons a minute. Here, also, efficient drainage is badly needed, though a stream of waste water reaches the Gulf.

Opposite Qatif across a shallow channel is Tarut Island with Dahrein village. There is a large spring here near the ancient Portuguese fortress (Fig. 32). The source of this water is undoubtedly the same as that of the springs on the mainland.

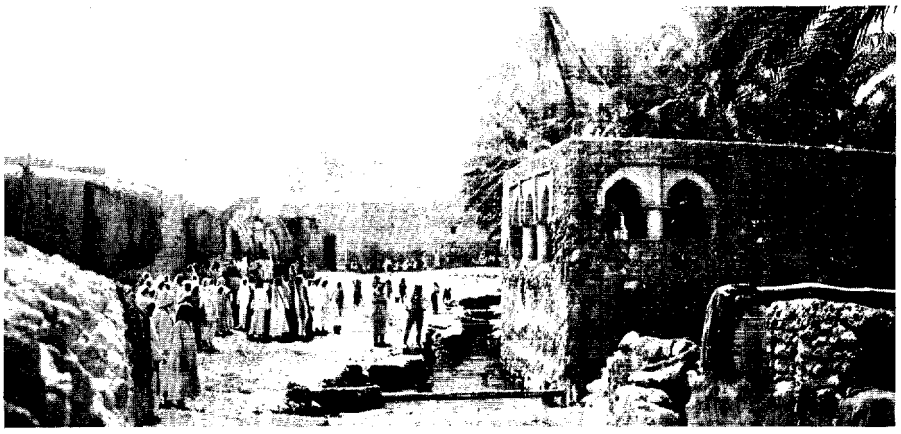

FIG. 31 Camels watering at Bir Ruma on the western edge of the Dahana.
FIG. 32 Spring and mosque, Dahrein, Tarut Island. Ancient Portuguese fort in the background.
FIG. 33 Huge spring and oasis, Darush, Safwa, west of Qatif.

The last water resource I shall note is that of the great Jabrin oasis, 160 miles southwest of Hofuf, at an average elevation of 700 feet (aneroid). This oasis covers an area estimated at 7500 acres and seems to be a catchment basin for rainfall. The water table during our visit in July, 1942, was 2 to 8 feet below the ground surface. It was reported that in winter much of the land is boggy, with standing water in places, a result of runoff and greatly decreased evaporation. There are many small pools, breeding places for mosquitoes so virulent that there are said to be no permanent inhabitants. The reported 400 families of the Murra tribe come only to pollinate the dates in the spring and to harvest them in the fall. King Ibn Saud attempted to establish a permanent Ikhwan settlement here, but after many deaths from malaria it was abandoned.

Under the present conditions of high salinity, dates are the only feasible crop. It is possible that an adequate drainage system could be installed, which would greatly improve living as well as crop conditions, but it would entail great expense and could only be done by the government and carried out by settlers who were much more agricultural-minded than the Murra tribesmen. As in so many places in Saudi Arabia, there are numerous ruins, indicating a larger population and agricultural development in the past.

Future Prospects

Under the sound government of the present ruler much has already been done to increase the agricultural production of Saudi Arabia, which in turn is dependent on the development of the water resources, and I feel confident that a foundation has been laid for further progress. The Crown Prince, Saud, his brother Prince Faisal—who has recently been visiting the United States—the minister of finance, Shaikh Abdulla Suleiman, and his brother Shaikh Hamad fully realize the importance of this type of work and are privately initiating extensive farming projects.